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TECHNOLOGY FOR DISMANTLING LARGE RADIOACTIVE STRUCTURAL COMPONENTS*

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ABSTRACT

The dismantling of the ERR (Elk River Reactor) was completed successfully and safely in September, 1974. This 58 MW(t), boiling water reactor was removed down to its foundations, and all of the radioactive material was shipped in suitable containers to licensed burial grounds. The most difficult and the unique part of this effort was the cutting up and removal of the radioactive structural parts, namely the inner thermal shield, the pressure vessel, and the outer thermal shield. The tools and techniques for this operation were designed, developed, and fabricated at the Oak Ridge National Laboratory. This development provides the nuclear industry with a viable alternative to entombment and surveillance for decommissioning reactors. This paper describes the technology used, and comments on its application to larger, more radioactive systems.

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INTRODUCTION

The Elk River Reactor (ERR) was a 58 MW(t) boiling water reactor, owned by Energy Research and Development Administration (ERDA) and operated by the United Power Association. It was shut down in 1968 after operating intermittently for three years. It was dismantled during the period from August 1971 to September 1974. A comprehensive description of the overall dismantling operation is given in Reference 1. The unique and difficult part of that operation was to cut up the large, highly radioactive structural components into pieces and transfer them into shipping casks. Almost all of the 10,000 Ci inventory was located in these structural components. The basic tool that was developed and used for this purpose was a remotely operated, underwater plasma torch.

The purpose of this paper is two fold: to present some details of the plasma torch technology used at the ERR, and to comment on some of the problems of applying this technology to typical power reactors at the end-of-life decommissioning. It is hoped that this information will prove helpful to those involved with making decisions in this area.

Description of the Equipment

The technology that was developed by ERDA specifically for the ERR makes it possible to cut remotely, automatically, and under water, with a plasma torch. Cuts of 1 1/2 in. thick stainless steel were made under water on the inner thermal shield. The pressure vessel, which was 3 1/8 in. thick carbon steel with a 0.109 in. stainless steel overlay, was cut in air. The outer thermal shield, consisting of carbon steel and lead, was cut with an oxy-acetylene torch in air. These vessels were approximately 7 ft in diameter and had contact readings of 1500, 250, and 1 R/hour, respectively. All of the equipment performed reliably and accurately. It was rugged, easy to learn to operate, and did not require lengthy set-up times.

The hardware components of this system consist of the plasma equipment, the manipulator, the control package, and an assortment of long handled mechanical tools. There are also a number of "software" items such as operating procedures, personnel training, plasma process parameters, etc. that are required. The plasma equipment consists of the torch, torch hoses, cables, power supplies, cutting gases, and accessories that are available from the welding equipment industry. The Linde PT-7 plasma torch was used because it had the highest capacity rating of any torch on the market. For this application a number of minor modifications to this hardware as purchased are required. The torch is shown under water in Fig. 1.

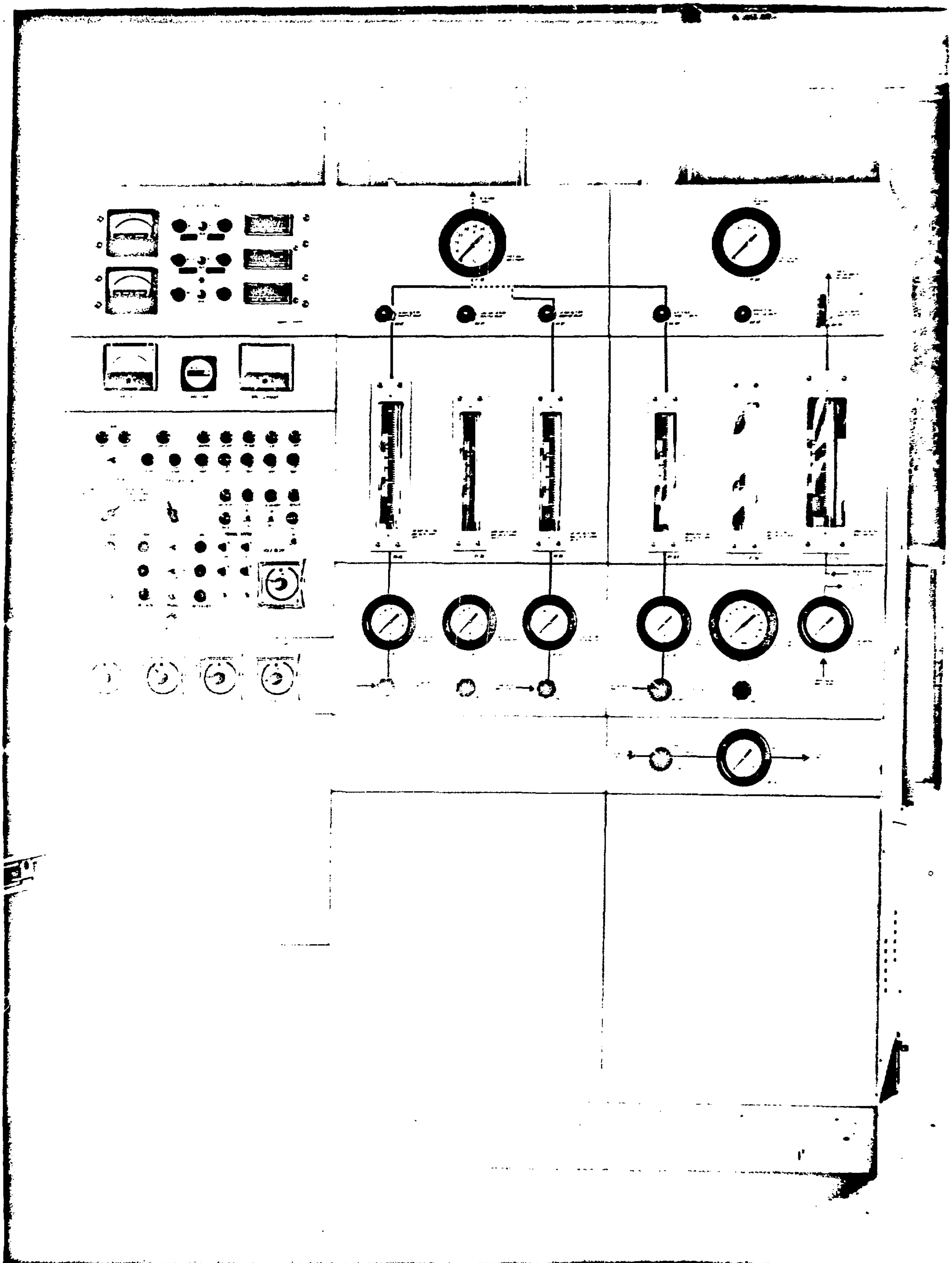
The torch is mounted on and moved by a manipulator. This is a special purpose, moderately sophisticated, one of a kind device. Its design was heavily influenced by the accuracy and rigidity requirements of the plasma cutting process. It weighs almost 4000 lbs and is 28 ft long. It has a 20 ft travel vertically and rotates 390°. In the radial direction the torch is forced outward to bear against the

metal to be cut, or it is completely withdrawn. Two arms, or torch holders, are used, one driven hydraulically for underwater work and an electrically driven arm for in-air cutting. The design of each arm reflects the criteria imposed by the cutting situation.

A control system controls the position and movement of the manipulator (thereby the torch), all of the cutting process parameters and a special sequence of operations. The panel shown in Fig. 2, which houses the controls, is located in an area remote from the manipulator and torch but connected by a bundle of hoses and power and signal wires. Included in this bundle are the following; air to keep water out of the torch, torch cooling water, nitrogen cutting gas, argon starting gas, d-c power to the torch, and to the drive motors, tachometer and position potentiometer signals, etc.

The cutting equipment is augmented with long handled tools for supporting and moving the cut segments and various other functions. Specially designed platforms, stands, and tool supports are also required and maintenance provisions have to be considered. In addition to the mechanical hardware, it is necessary to test the components both separately and assembled and to develop by trial and error the cutting parameters that would give the most satisfactory results. The development work of this type for ERR was done on small samples wherever possible.

With the equipment described and the general techniques used at the ERR, the Sodium Reactor Experiment (SRE) near Los Angeles will also be dismantled. Atomics International (AI) has acquired from ORNL,



the control panel, which was salvaged from the ERR operation, and all of the drawings of the manipulator. The radioactive parts of the reactor will be removed, the building decontaminated, and responsibility for the site will be transferred from ERDA to AI. The work is scheduled for completion late in 1978.

Comments and Observations on Using the Plasma Torch Technique

It has been shown that dismantling is feasible and practical for small reactors that have not operated for long times. Is it feasible, safe, and practical to use the same technique on a large reactor at the end of its service life?

The two items that strongly influence this question are the increased thicknesses of the various vessels and the increased radiation levels. Modern carbon steel pressure vessels are in the range of 9 in. thick with a 0.25 in. stainless steel overlay. Thermal shields are 2.75 in. thick stainless steel. Cutting these metal thicknesses with the underwater plasma torch has not been demonstrated. Further it is expected that all of these structures would have unusual geometries such as at penetrations, reinformcements, attachments, etc. A development program would be required to demonstrate the ability to cut these thicknesses and special geometries.

The increased radiation levels, however, are the major concern. These levels can be from 10^3 to 10^5 times that encountered at the ERR. Costs of shipping and operations would be strongly influenced by the total curie inventory. Protection of the operating crew would be extremely difficult. The necessary technqiues have not been demonstrated and need to be developed. The procedure used at the ERR was first to cut up and remove the reactor internals from inside the pressure vessel, using water shielding. Then the inner thermal shield was cut under water by the plasma arc. Thus, with water shielding, the most radioactive components were handled in a straightforward way. From this point on, the cutting was done in air. Although the most radioactive components had already been removed there were higher levels of radiation during this latter operation and consequently higher crew exposures. This experience suggests to the author that the critical points to be evaluated are the radiation levels that exist at the time when there is no longer water shielding available. The time honored means to overcome the above problem, i.e., remote operations and more shielding, translate into increased costs.

In the area of waste management the record at the ERR was quite satisfactory. Established health physics field techniques and equipment were used in controlling contamination and in monitoring a wide range of environmental situations. Also there was close cooperation with the dismantling operations group in controlling potential contamination produced by the plasma-arc process. The underwater cutting produced very little airborne contamination while frequent changes of the HEPA filters in the exhaust system were required for in-air cutting.

The reservations stated above can be summed up as follows:

1. The technique cannot be applied in a rubber stamp fashion to any given reactor or radioactive system.

2. To establish whether this method is feasible for use on any specific situation it is suggested that as a minimum, an engineering

effort is required that would consist of three parts: (a) a thorough analysis of the curie inventory and the resultant radiation levels in the plant, (b) a preliminary plan of action similar in content and detail to the Activity Specifications[1] used at the ERR and (c) a cost estimate. Details of this effort are suggested in Table 1.

3. Further development of the technique is necessary to demonstrate the capability of cutting the increased thicknesses of large pressure vessels and components. Development efforts beyond the absolute minimum requirements may lead to new dismantling technqiues that would make the process easier and cheaper.

To sum up, the underwater plasma arc technology, holds promise in the field of decommissioning, but should be applied with caution, solid engineering, planning, and forethought.

Table 1. Proposed engineering analysis to establish the feasibility for using plasma torch dismantling.

Item	Estimated Effort (manyears)
1.0 Analysis of radiation	.3
1.1 Curie inventories	
1.2 Resultant radiation levels	
1.3 Shielding for operations	
1.4 Shielding for shipping	
2.0 Plan of action	1.5
2.1 General procedure	
2,2 Cutting operations	
2.3 Contamination control and environmental protection	
2.4 Transfer operations	
2.5 Shipping	
2.6 Development required	
2.7 Alterations to the building	
2.8 Special problems	
3.0 Cost estimate	.2
3.1 Site alteration	
3.2 Development	
3.3 Equipment	
3.4 Operations – Labor	
3.5 Operations – Materials	
3.6 etc.	
Total	2*

*over a 6 month time span

REFERENCES

1. United Power Association, Elk River, Minn. "Final Elk River Reactor Program Report" COO-651-93, September, 1974, revised November 1974.

2. J. F. Nemec, R. M. Beckers, and R. Blumberg, "Radioactive Operations in the Dismantling of the Elk River Reactor" Proceedings of the American Nuclear Society, 19th Annual Meeting, Chicago, Illinois, June 1973.

FIGURES